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Supercomputer Simulation Wins Gordon Bell Award for Livermore Lab

PORTLAND, Ore. — A team led by the Department of Energy's Lawrence Livermore National Laboratory, collaborating with the University of Minnesota and IBM, solved a supercomputer problem with broad applications including supernova evolution, combustion physics, and supersonic vehicle propulsion and dynamics. Their efforts were awarded supercomputing's 1999 Gordon Bell Award for best performance.

Announced November 18, at the Supercomputing '99 Conference in Portland, Oregon, the Gordon Bell Prize started in 1988 to recognize the most significant achievements applying high-performance computers to scientific and engineering problems. The award-winning submission was "Very High Resolution Simulation of Compressible Turbulence on the IBM-SP System." The team studied the resultant turbulence when a shock-wave passes through the interface of two fluids.

"A turbulence simulation of this level of detail — what we refer to as 'resolution' — has never been conducted before. Such high resolution simulation, when linked with complementary laboratory or field experiments, has the potential to lead to scientific breakthroughs in a variety of disciplines," said Bill Dannevik, principal investigator on the project.

"The unprecedented resolution of this study enabled us to explore for the first time the interaction of significantly disparate length scales of fluid motion and how this might impact the reactivity of the interpenetrating fluids," said Ron Cohen, the co-principal investigator.

Art Mirin of Livermore coordinated the award-winning simulations and the team presentation at the Supercomputing '99 Conference. Other team members were Bruce Curtis, Andris Dimits, Mark Duchaineau, Don Eliason and Dan Schikore of Livermore; Sarah Anderson, David Porter and Paul Woodward of the University of Minnesota; and Danny Shieh and Steve White of IBM.

The simulations addressed the interaction of disparate-length scales in three-dimensional Richtmyer-Meshkov mixing. Richtmyer-Meshkov instability arises when a shock passes through the interface of two fluids having different mass densities. It is important in applications such as chemically-reactive flows and combustion.

A series of three-dimensional simulations, using codes initiated by Woodward of the University of Minnesota, was performed on the IBM Sustained Stewardship TeraOp system, developed for the Accelerated Strategic Computing Initiative program at LLNL. ASCI is a key component of DOE's science-based Stockpile Stewardship Program, which ensures the safety and reliability of U.S. nuclear weapons without underground testing.

A proof-of-principle simulation using more than 24 billion zones was clocked at 1.18 Teraflops (trillion floating operations per second) on 5,832 processors of the IBM RS/6000 SST system. An 8-billion zone long-time simulation, emulating a shock tube experiment at Caltech, executed for 27,000 time-steps, represented over 300 quadrillion arithmetic operations. The calculations took slightly more than a week, and produced over 3 terabytes of data.

"This project is an example of Laboratory excellence through interdisciplinary teams and vigorous interactions with academia and industry," said Dannevik..

For more information or to read the technical paper describing the prize-winning calculation, see http://www.llnl.gov/CASC/asciturb/publications.shtml.

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